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SILT EROSION IN HYDRO TURBINES AND STATUS OF SMALL HYDROPOWER IN INDIA - A REVIEW

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ABSTRACT

Small hydropower is cleanest wellspring of energy. In India, the plants up to 25 MW are considered as small hydropower plant. In India and across the globe, hydro power plants are facing erosion problems due to Silt. Silt molecules that move through hydro turbine segments cause erosion to the surface which interacts with it. Silt size, concentration, velocity of flow, properties of silt materials and working hours of turbine assume a fundamental part in harm to the turbine segments. The proficiency of the turbine diminishes with increment in erosive wear. The present study is based on review of Small hydro power status in India and its biggest enemy is erosion in hydro turbines due to silt. In this present paper, the studies related to small hydro power and silt erosion by various investigators have been presented. The studies presented by various investigators are based on experimental work, numerical simulation and case studies.

KEYWORDS: Hydropower, Energy & Erosion

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Original Article

INTRODUCTION

The development of infrastructure is important to sustain economic growth of any country and energy sector is one of the most important constituents of the infrastructure. Demand of energy is continuously increasing as industrialization and population are increasing day by day [1].

There are two types of energy sources non-renewable and renewable. Non-renewable energy sources (coal, nuclear energy, oil and natural gas) are continuously depleting and creating pollution problems as energy demand is continuously increasing. Renewable energy sources are hydro, solar, geothermal, wind, tidal and biogas. Renewable energy sources are cheaper, environment friendly, inexhaustible and abundant in nature [1-2]. Among all renewable energy sources, the small hydro is the cleanest source of energy and it is the most promising source to produce electricity [3-6]. Hydro power is to direct renewable origin for electricity generation universally, supplying 71 % of all renewable electricity. In 2016, the total installed capacity of Hydropower is 1, 064 GW and it is generating 16.4% of the world's electricity from all sources. The top countries for hydropower capacity remained (Figure 2) China, Brazil, Canada, United States, Russia, Norway and India. They together accounted about 63% of global installed capacity [7]. The plants which generate electricity up to 25 MW are classified as small hydropower (SHP) in India [8]. In 2016 globally installed SHP capacity is 78 GW. SHP represents approximately 1.9% of world's total power capacity, 7 % of the total renewable energy capacity. As shown in Figure. 3. SHP is fifth in development, but large hydropower is having the highest installed capacity till date [9]. The estimated potential of SHP in India is about 20,000 MW from (6474 sites). The total installed capacity of SHP

in India is 19,749.44 MW from (997 sites) as on 31st March, 2014 [10]. Figure1 shows Installed capacity by source generation in India is the elementary necessity for economic development of a country.

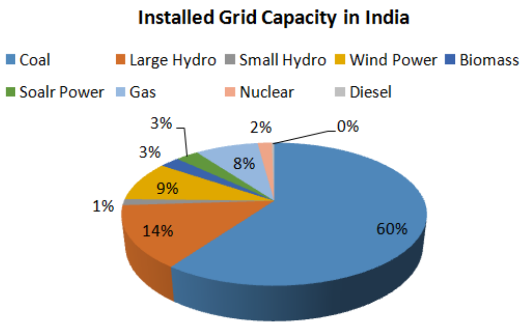

Figure 1: Installed Grid Capacity from all Sources in India [12]

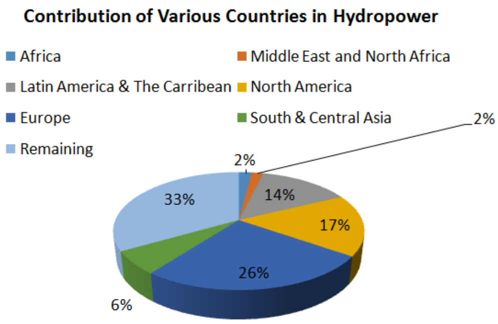

Figure 2: Contribution of Countries Producing Hydropower [13]

The developing interest for energy has come about relying over the fossil fuels. India has an extensive potential in the scope of large and small hydropower projects. Because of characteristic disadvantage related to large hydro (huge development periods, submergence of extensive zones alongside vegetation, recovery and so forth.), small hydropower is thought to be the reasonable source of power generation [11]. Figure.4 showing a schematic of small hydropower plant. Across the globe, hydropower plants are facing silt erosion problems.

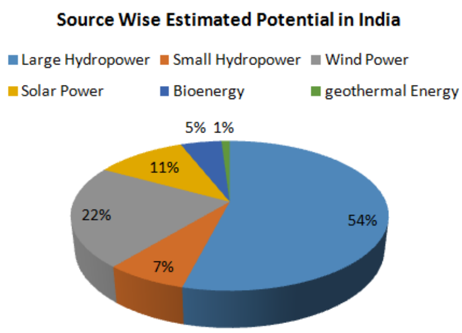

Figure 3: Source Wise Estimated Potential in India [14]

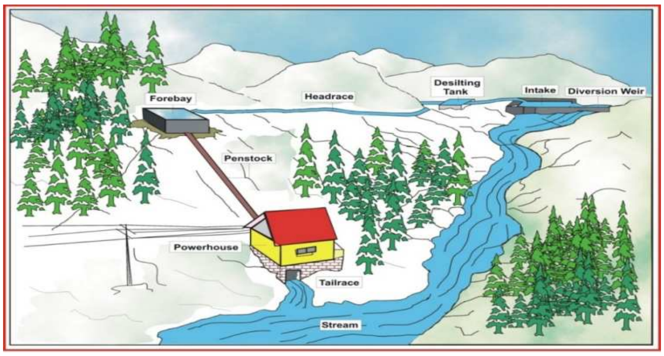

Figure 4: Schematic of Small Hydropower Plant [2]

The harm due to erosion in general considered as a continuous evacuation of material caused by repeated deformation and cutting activities. Erosion due to silt in hydro turbines is perplexing marvel that relies upon silt size, silt concentration, jet velocity, working hours of turbine, jet diameter and nozzle angle [15-18].

Small hydropower plants, are inclined to silt which are extremely destructive to hydro-mechanical gear arranged in Himalayan and North Eastern area of India and many places over the globe [19-21]. During rainy season, the concentration of silt increments exponentially doing harm to turbine segments because of erosion [22].

This problem is exasperate, when silt contains exceedingly hard material namely quartz which cause erosion in hydro turbine equipment [23, 24]. This problem is very critical for any developing country like India economically [25]. Erosion in hydro turbines not only demands overhauling or replacement of runner, but the efficiency of hydro turbines also decreases which increases maintenance cost [26]. Buckets, nozzle, faceplates, guide vanes, blades, ring liners are more prone to silt erosion. The size, shape, density, concentration, hardness and constituents of silt particles assume to be extremely imperative part in the degree of harms. Foreseeing turbine erosion in genuine stream conditions is a troublesome assignment.

SILT EROSION IN HYDRO TURBINES

Khurana et al. [24] have developed a correlation for erosion due to silt in Turgo impulse turbine runner experimentally in actual flow conditions as shown in Figure 5. They have observed that erosion in hydro turbines is strongly dependent on critical parameters i.e., silt size, silt concentration, jet velocity, working hours of turbine. Using experimental data, correlation developed is as follows:

$$W = 1.976 \times 10^{-10} S^{0.118} C^{0.967} V^{1.368} t^{1.117}$$

Figure 5: Eroded Bucket of Aleo Power Plant Manali (India) [30]

Khurana et al. [21] experimentally investigated the impact of silt erosion on the performance of Turgo impulse turbine blades. The experiment was performed to study the effect of silt size, silt concentration, velocity of flow and working hours of turbine on the decline efficiency of the Turgo impulse turbine. They have observed that these parameters are responsible for the loss in efficiency of the turbine. They have developed a correlation by using experimental data as:

$$\eta_{\%} = 2.93\times10^{-8}\ (S)^{0.212}\,(C)^{1.113}\,(V)^{1.368}\,(t)^{1.117}$$

Padhy and Saini [27] performed experiments on a small scale Pelton turbine to study the effect of silt parameters and operating parameters on erosion in buckets. They have developed a correlation of the above said parameters as:

$$W=2.43\times10^{-10}\ (S)^{0.099}(C)^{0.93}(V)^{3.40}(t)^{0.75}$$

Gohil and Saini [18] have conducted a review on Coalesced effect of cavitation and silt erosion in hydro turbines. In their review paper they have included some experimental studies, theoretical investigations, numerical studies related to silt erosion and cavitation in hydro turbines till 2013.

Singh and Chandra [28] revealed the contextual analysis of the Tiloth hydro control station (3 ×30 MW) on river Bhagirathi (India). The three units were dispatched in the last quarter of 1984. The turbines were observed to be seriously harmed after around 2600 hours of operation. They were repaired, yet again, in 3000 to 5000 hours of operation, broad harm was watched. The sedimentation chamber was intended to capture silt particles bigger than 0.3 mm. In light of petrographic studies done, the presence of exceedingly grating quartz having hardness of 7 on Moh's scale was uncovered. The concentration of the sediment particles during the rainy season was discovered most extreme which has come up to 4000 ppm. At first, there was a proposition to give another sedimentation chamber to capture particles up to 0.15mm. Be that as it may, because of high cost and as the settling chambers couldn't totally evacuate the residue particles, the proposal was not executed. The examiners, rather, recommended enhancing the metallurgy of the turbine cutting edges. The new runner was produced with stainless steel (13Cr4Ni), which should give a superior execution in regards to disintegration. Be that as it may, it was watched that there was no apparent lessening in disintegration contrasted with the more established runners.

Prasad et al. [29] has carried out 3D real flow analysis is an experimentally tested oral flow turbine and diffident flow parameters are computed at these operating regimes to fund the best operating regime using ANSYS CFX 10 software the computed efficiencies are erotically compared with experimental volume and found to bear close comparison.

Thakur et al. [30] have conducted case studies of sand erosion for Chamera power house having three units of Francis turbine and for Aleo power houses in Manali having Pelton Turbine. First unit (Chamera I) produces 540 MW (3×180 MW), Chamera II produces 300 MW (3×100 MW) Chamera III produces 231 MW (3×77 MW) and Aleo Power house in Himachal Pradesh (India) having (2×1.5 MW) capacity.

LITERATURE REVIEW ON SMALL HYDROPOWER

Yah et al. [31] presented a review on Small scale hydro-power as a source of renewable energy in Malaysia. In their paper they have discussed about the present potential of small hydropower in Malaysia. They have found that an estimated hydropower resource in Malaysia is 29,000 MWof which 500 MW is from small scale hydropower. They have mentioned that the government of Malaysia will achieve a target of 490 MW from small hydropower by 2020.

Table 1 also shows all India Capacity in MW of Various Power Stations [33].

Table 1: All India Capacity in MW of Various Power Stations

All INDIA INSTALLED CAPACITY (IN MW) OF POWER STATIONS (As on 28.02.2017) (UTILITIES)									
REGION	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Nortern Region	State	16598.00	2879.20	0.00	19477.20	0.00	8478.55	663.56	28619.31
	Private	17926.00	558.00	0.00	18484.00	0.00	2505.00	9583.42	30569.42
	Central	12000.00	2344.06	0.00	14344.56	1620.00	8266.23	0.00	24230.79
	Sub Total	46524.00	5781.26	0.00	52305.76	1620.00	19246.78	10246.98	83419.52
Western Region	State	22920.00	2993.82	0.00	25913.82	0.00	5480.50	311.19	31705.51
	Private	36895.00	4676.00	0.00	41571.00	0.00	447.00	16549.95	58567.95
	Central	12898.01	3533.59	0.00	16431.60	1840.00	1520.00	0.00	19791.60
	Sub Total	72713.01	11203.41	0.00	83916.42	1840.00	7447.50	16861.14	110065.05
Southern Region	State	17372.50	791.98	287.88	18452.36	0.00	11739.03	512.55	30703.94
	Private	9590.00	5322.10	473.70	15385.80	0.00	0.00	21208.87	36594.67
	Central	12690.00	359.58	0.00	13.49.58	2320.00	0.00	0.00	15369.58
	Sub Total	39652.50	6473.66	761.58	46887.74	2320.00	1739.03	21721.42	82668.19
Eastern Region	State	7025.00	100.00	0.00	7125.00	0.00	3537.92	225.11	10888.03
	Private	8731.38	0.00	0.00	8731.38	0.00	195.00	671.52	9597.90
	Central	14091.49	0.00	0.00	14091.49	0.00	1005.20	0.00	15096.69
	Sub Total	29847.87	100.00	0.00	29947.87	0.00	4738.12	896.63	35582.62
North Eastern Region	State	60.00	492.95	36.00	588.95	0.00	382.00	259.25	1230.20
	Private	0.00	24.50	0.00	24.50	0.00	0.00	21.19	45.69
	Central	250.00	1253.60	0.00	1503.60	0.00	860.00	0.00	2363.60
	Sub Total	310.00	1771.05	36.00	2117.05	0.00	1242.00	280.44	3639.49
Islands	State	0.00	0.00	40.05	40.05	0.00	0.00	5.25	45.30
	Private	0.00	0.00	0.00	0.00	0.00	0.00	6.15	6.15
	Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sub Total	0.00	0.00	40.05	40.05	0.00	0.00	11.40	51.45
All India	State	63975.50	7257.95	363.93	71597.38	0.00	29618.00	1976.90	103192.28
	Private	73142.38	10590.60	473.70	84196.68	0.00	3144.00	48041.10	135381.78
	Central	51930.00	7490.83	0.00	59420.83	2780.00	11651.43	0.00	76852.26
	Sub Total	189047.88	25329.38	837.63	215214.89	5780.00	44413.43	50018.00	315426.32

Gaviria et al. [32] have investigated the prospects of small hydropower in Colombia for grid connected small hydropower stations. Their investigation was based on economies–of-scale and learning by doing for small hydropower in Colombia. They have built the database for installing small hydropower for 13 years and their database contains information on capacity, installation year, location, present state and the cost of investment.

Nautiyal et al. [1] led an audit on small hydropower for sustainable energy advancement in India. In their study they have highlighted the water assets and small hydropower potential in India. They have talked about that 16% of small hydropower has been produced for power generation. They have displayed small hydropower sources for sustainable development.

CONCLUSIONS

The present work has been conducted to review the work conducted by various investigators in their earlier studies. In this present work, studies related to small hydropower and silt erosion in hydro turbines have been presented in the form of some experimental work, numerical simulation and the case studies conducted by various authors. It has been observed that small hydropower is clean and environmental friendly source of energy. Even in remote and rural areas supplying electricity through small hydropower is very useful. In India and across the globe, hydropower plants facing the problem of erosion due to silt. Silt erosion depends on silt size, concentration, velocity of flow, working hours of turbine and jet diameter. Due to silt, efficiency of hydro turbines decreases, which cause economic loss to developing and developed nations. The government of India is trying hard to establish small hydropower plants in the country.

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